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MEASUREMENT OF IMPULSE NOISE OF VEHICLES AT THE STANLEIGH URANIUM MINE IN ELLIOT LAKE

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by

M.U. Savich* and D. O'Connor**

ABSTRACT

Measurements and evaluations for determining 'Peak' levels of short duration and the impulse noise of vehicles were done for the following engine states: wide open throttle (W.O.T.), IDLE, and under the working conditions of moving up a slope (UP) and down a slope (DOWN).

The mean value of all measurements performed is about 11 dBA. Industrial impulse noise contains a significant amount of energy in the 4-6 kHz range, which is also the region in which hearing loss usually first occurs. This frequency range, according to one group of authors, should be measured separately and taken into account when evaluating the noise exposure index (NEI). Another group of authors rejects this view and advances the view that for steady, intermittent and varying noise, including impulse noise, we need have only one scientifically acceptable basis for the measurement of noise exposure: 'integrated squared A-weighted sound pressure' with a determined integration period (ISO/R 1999-1984).

Measuring in detail the magnitudes of impulse noise, time durations and the number of impulses per shift, and then making a comparative analysis using audiometric tests, will show us the extent of this problem in Canadian mines.

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MESURE DES VIBRATIONS SONORES PRODUITES PAR DES VÉHICULES À LA MINE D'URANIUM STANLEIGH D'ELLIOT LAKE

par

M.U. Savich* et D.O. O'Connor**

RÉSUMÉ

On a pris des mesures et fait des évaluations visant à déterminer les niveaux maximaux d'intensité sonore de courte durée et des vibrations sonores produites par des véhicules en faisant tourner un moteur au régime suivant: à pleine charge (WOT), à charge au ralenti et en situation de service, soit en montant une pente (UP) ou en descendant une pente (DOWN).

On a établi la valeur moyenne de toutes les mesures du bruit à environ 11 dBA. Les vibrations sonores provenant des machines recèlent une quantité importante d'énergie dans la gamme des fréquences 4 à 6 kHz qui est aussi la zone de modulations qui provoque habituellement la surdité. Selon un groupe d'auteurs, cette gamme de fréquences devrait être mesurée séparément et on devrait en tenir compte lorsque l'on fait l'évaluation de l'indice d'exposition au bruit (IEB). Un autre groupe rejette cette opinion et soutient que les bruits réguliers, intermittents ou variés y compris les vibrations sonores peuvent être mesurés à l'aide d'une mesure de l'exposition au bruit scientifiquement acceptable soit la 'mesure du niveau acoustique global pondéré A au carré' au cours d'une période déterminée (ISO/R 1999-1984).

La mesure du détail de l'ampleur des vibrations sonores, de la durée et du nombre d'impulsions par quart de travail et enfin l'analyse comparative au moyen de tests audiométriques démontrera l'envergure de ce problème dans les mines canadiennes.

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INTRODUCTION

The Stanleigh uranium mine in Elliot Lake was opened for large scale production of ore in 1983, using a very modern process. It has five spiral levels, which facilitate the moving of equipment from one level to another (Fig. 1) (Appendix A 1-5). The spiral levels are themselves the reason why measurements were taken at the mine, because they provide a unique opportunity to test loaded and unloaded vehicles when moving up or down slopes to change levels.

The purpose of these measurements was to find differences between sound pressure levels in dBA and Peak levels (impulse or impact noise), and to find an explanation for the hearing loss at 4-6 kHz by vehicle operators in mines. Impulse or impact noise is defined as a sound which reaches peak intensity within a rise time of not more than 30 milliseconds and has a duration of not more than 500 milliseconds.

EXPOSURE TO NOISE

In exposure evaluations of steady and intermittent noise, two concepts have been predominant: the 'total energy theory' and the 'principle of equinocivity'. The 'total energy theory' is determined by the average noise - induced hearing loss within a representative population, or more simply by the total amount of A-weighted sound energy received by the ear. Noise exposure evaluations, where the rate at which damage accumulates is directly proportional to sound intensity, are carried out daily. This means that a 3 dB increase in the sound level corresponds to a halving of the exposure time. The 'principle of equinocivity' has a close relationship between the temporary

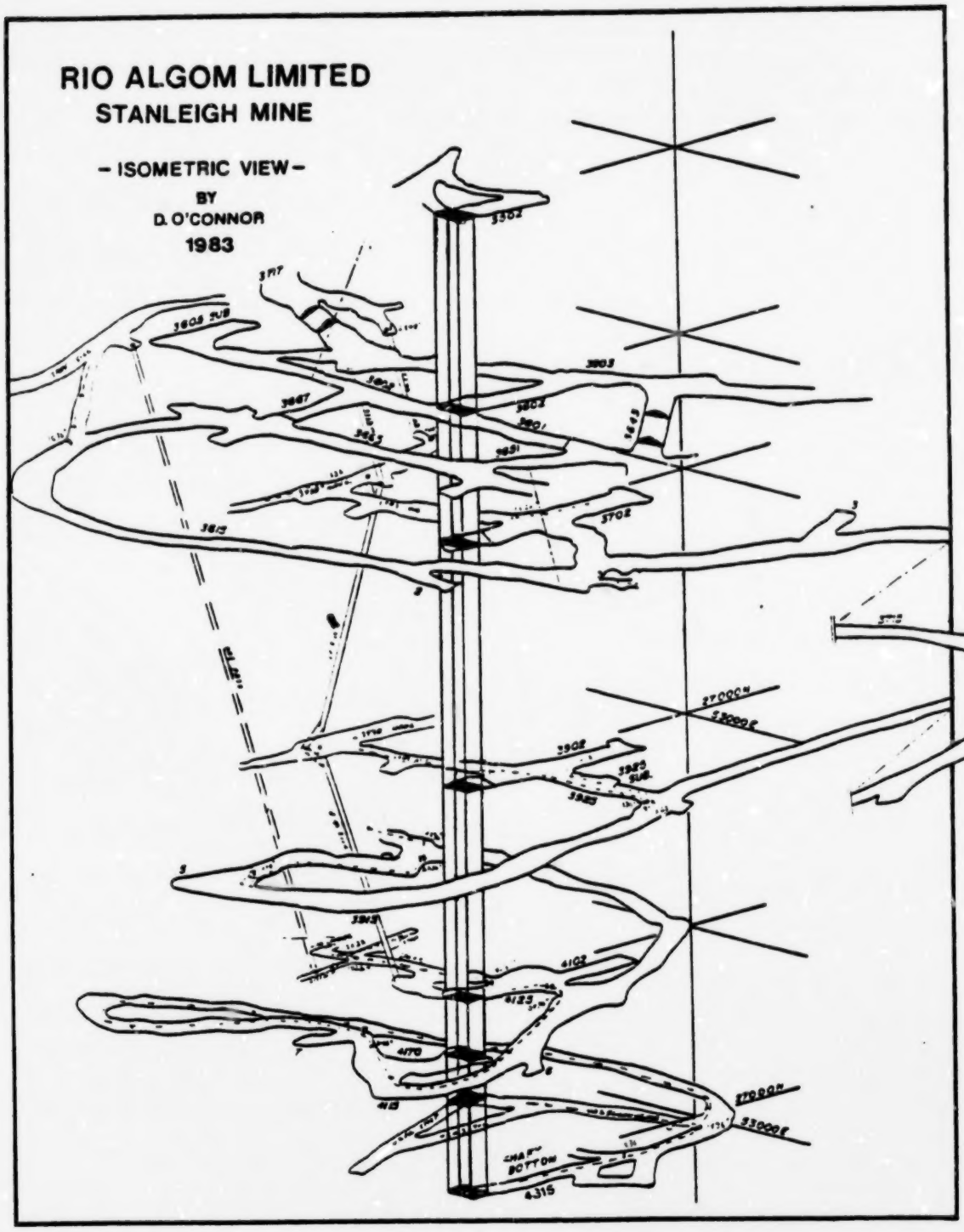

Fig. 1 - Isometric view of the Stanleigh uranium mine.

threshold shift (TTS) measured at the end of the working day and the permanent noise - induced threshold shift (PTS). The '5 dB rule' has been predominant in North American noise regulations in the last decade. In these regulations, a threefold increase in sound intensity, by the factor of $\sqrt{10}$, corresponds to a 5 dB increase in sound level, which is traded against a halving of daily noise duration. The total energy in the exposure is increased by a factor of 1.5 (i.e., 3 x 0.5). "Since the reduction in total duration could be brought about by appropriate intermittency, the 5 dB rule would, in such circumstances, be qualitatively consistent with TTS experiments and, by inference, with the 'principle of equinocivity'. There is, however no guarantee of intermittency since the 5 dB rule makes no distinction between interrupted and uninterrupted exposures"(1).

Measurements performed at the Denison Mine in Elliot Lake have shown that industrial noise there, was interrupted several times per day before lunch and several more times afterwards (2-4). Sometimes it happens that machines remain turned off before lunch and sometimes after. Such a phenomenon supports the 5 dB rule (5).

A broad discussion is still taking place on whether to introduce the 3 dB rule (ISO), or retain the old 5 dB one (OSHA). Literature on this topic will not be cited because it is beyond the scope of this report. Scientific support has for the most part been behind the new ISO document entitled "Determination of Occupational Exposure and Estimation of Noise - Induced Hearing Loss" (ISO, 1984); and the document received approval in February 1984 for publication as a new edition of ISO 1999. The definition of 'time-integral of the squared A-weighted sound pressure' is equivalent to the 3 db trading relationship. It should be noted that the following sentence shows the comprehensive relationship among different types of noise:

intermittent, fluctuating, irregular or impulsive in character: Use of this International Standard for instantaneous sound pressures exceeding 200 Pa (140 dB relative to 20 Pa) and for higher sound pressure levels should be regarded as extrapolation."

The method presented in ISO/DIS 1999-1984 is based on a measurement of the 'time integral of the squared A-weighted sound pressure' for a longer period, for example, a working week. At the Fourth International Congress on Noise as a Public Health Problem held in Turin, Italy in June 1983, the workshop Memorandum recognized that 'impulsiveness' requires 'characterization in relation to its biological significance' (1). At this meeting there was a clear statement that a minimum of five years of research would be needed before the method of ISO/DIS 1999-1984 could be improved upon.

The importance of this problem will be explained briefly. For more than forty years it has been known that hearing loss starts in the 4-6 kHz range (C_5-dip), despite the fact that industrial noise has a higher intensity in the frequency range of 250-500 Hz than in the 4-6 kHz range. "There has been considerable speculation as to why hearing loss due to industsrial noise occurs 3 octaves higher on the frequency scale than the corresponding frequency region with the most energy content, and no sensible explanation has been given to date." (6).

In 1976, P.V. Bruel explained why hearing loss always starts around 4-6 kHz and also why the risk of hearing loss is considerably higher in this case than that given by the total noise dose criterion. In his practical examples and measurements he showed that risk criteria must take into consideration the total noise dose as well as the impulsive content of the noise.

Many authors are opposed to the above mentioned view of P. Bruel, and

they may very well be right in certain cases or jobs. To assess these opposing views we undertook to perform approximate measurements; measuring only the 'peak' and not its duration or number of impulses. Measuring the last two would have required more sophisticated instruments and the concomitant investment.

INSTRUMENT

All measurements were taken using the Bruel and Kjaer Integrating Sound Level Meter Type 2225. The 2225 was designed to assess hearing and has a choice of four functions: 60s L_{eq}, Fast, Slow and Peak. The maximum peak value occurs before the instrument is reset. The PEAK function better than $\pm$ 0.1 dB/s uses a rise time of 30 µs, which is very important for assessing hearing damage risk.

The Sound Level Meter (SLM) was carried in an aluminum case (7). The case has a wide strap, allowing the SLM to be carried over a shoulder for easy 'hands-off' transportation . The Noise Survey Form was designed and produced in book form to be used with the aluminum case. The case was built at the Elliot Lake Laboratory.

MOBILE EQUIPMENT IN MINE

All mobile equipment should be classified under three categories:

- trucks
- tractors, and
- load-Haul-Dump (LHD) machines.

Noise sources of these machines are (8):

- engine airborne noise from the engine or block structure;
- engine structure-borne noise caused by engine vibrations

throughout the machine's structure;

- auxiliary-component noise from the transmission and hydraulic system;
- fan noise;
- exhaust noise;
- air intake noise from the intake and structural radiation from the intake piping.

At the component source levels, the highest levels are produced by engine and exhaust outlet noise.

Sound pressure level and Peak level were taken from vehicles on five levels of the mine. The largest number of measurements were taken at the 3500 and 3600 levels (Appendix A 1-2). One factor for tests to be successful was to retain an underground mining environment and its reverberation. Rerverberation time, T, is defined as the time required for the sound to decay 60 dB. Absorption properties of stones and concrete vary with frequency, as does reverberation time.

Usually, reverberation time is calculated for the single frequency of 500 Hz. Reverberation time depends upon tunnel dimensions and the total absorption of the room:

$$T = 0.161(\frac{V}{A})s$$

where, T = reverberation time (s)

V = volume of the space (m^3)

A = total absorption of the space (metric sabins).

The larger the tunnel or underground area, the greater will be reverberation time. Another factor in successfully completing the tests was to perform measurements on as many types of vehicles as possible without interfering in the continual operations of the mine. In plans of levels 3500,

3600, 3700, 3900 and 4100, places where measurements were taken ('test location') are numbered so as to correspond to numbers in Appendix B 1-5.

MEASUREMENT RESULTS

Seventy-six measurements were carried out on 15 types of vehicles:

Engine states (Appendix B 1-4):

- W.O.T. (21) } Measurement taken at operator's ear
- IDLE (17) }

Working condition (Appendix B 1-3 and 5):

- UP (up a slope) (19) } Measurement taken beside moving vehicle
- DOWN (down a slope) (19) } for approximately 1 m

Where more measurements were taken on the same type of vehicle, it is so noted in the columns, "No. of Vehicles". For example, in Appendix B-4, No. 10; Appendix A 1 and 2 have three vehicles. Mean values have been found where many measurements were taken. Measurement results are tabled in Appendix B 1-5. Differences between equivalent levels and sound pressure levels are from 0 to 2 dBA, but for our purpose of cursorily investigating the problem, this does not make for great errors. Errors which occurred during measuring have for the most part been equalized.

W.O.T

Figure 2 gives the results for the W.O.T. state of the engine, where the mean was calculated to be 12.11 dBA and the standard deviation 1.92 dBA. The largest difference between the sound pressure level in dBA and the peak value was with the No. 4 tractor (34 hp), a difference of 16 dBA; and the smallest difference was with the telescope dump truck (231 hp), a difference of 6.5 dBA. This proves the maxim that the more powerful motor does not necessarily have to be louder, because the larger mass can successfully dampen

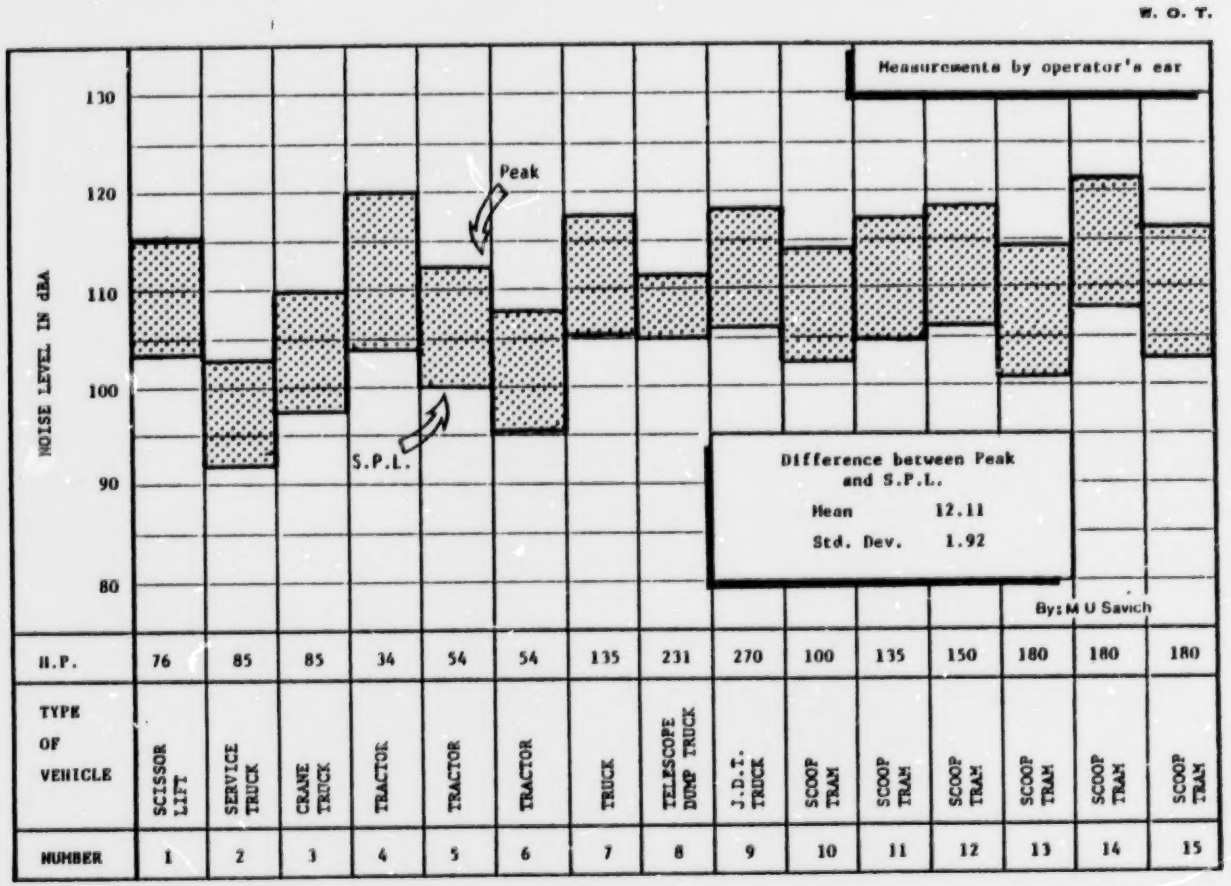
W. O. T.
Measurements by operator's ear
NOISE LEVEL IN dBA
130
120
110
100
90
80
Peak
S.P.L.
Difference between Peak and S.P.L.
Mean 12.11
Std. Dev. 1.92
By: M U Savich
H.P. 76 85 85 34 54 54 135 231 270 100 135 150 180 180 180
TYPE OF VEHICLE SCISSOR LIFT | SERVICE TRUCK | CRANE TRUCK | TRACTOR | TRACTOR | TRACTOR | TRUCK | TELESCOPE DUMP TRUCK | J.D.T. TRUCK | SCOOP TRAM | SCOOP TRAM | SCOOP TRAM | SCOOP TRAM | SCOOP TRAM | SCOOP TRAM
NUMBER 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Fig. 2 - Graph of differences between the sound pressure level in dBA and the peak value for all vehicles at the W.O.T. state of the engine at Stanleigh Mine.

noise and vibration. All other results are almost equal to one another, with small variation.

IDLE

Figure 3 gives the results for the IDLE state of the engine. Here the mean was calculated to be 11.61 dBA with a s andard deviation of 2.18 dBA. Scooptram No. 10 yields a very small difference between SPL and Peak level, for a reason which has not been determined. The difference should be 5 to 6 dB greater than it is. Nevertheless, because of reasons mentioned earlier, this result was not discarded. For the most part, all other results are similar and vary from 10.7 dBA to 13.9 dBA.

UP

Figure 4 shows the results for vehicles moving up a slope with a surveyor measuring noise from 1 m beside the moving vehicle. Here results can be divided into two groups:

1) 7.3 dBA to 10.4 dBA - 7 samples
2) 10.5 dBA to 13.9 dBA - 5 samples

Total 12 samples

These two groups are the result of variations in the following:

- distance between microphone and vehicle (surveyor's position)
- vehicle load
- vehicle position (left or right side)
- maintenance, and
- vehicle asymmetry.

After calculations, the mean and standard deviation are 9.96 dBA and 1.84 dBA, respectively. The largest difference between SPL and Peak level is 13.9 dBA yielded by No. 11 scooptram (135 hp). Each result would have to be discussed separately. Only a large number of measurements and a detailed study of vehicles could correct and explain these results.

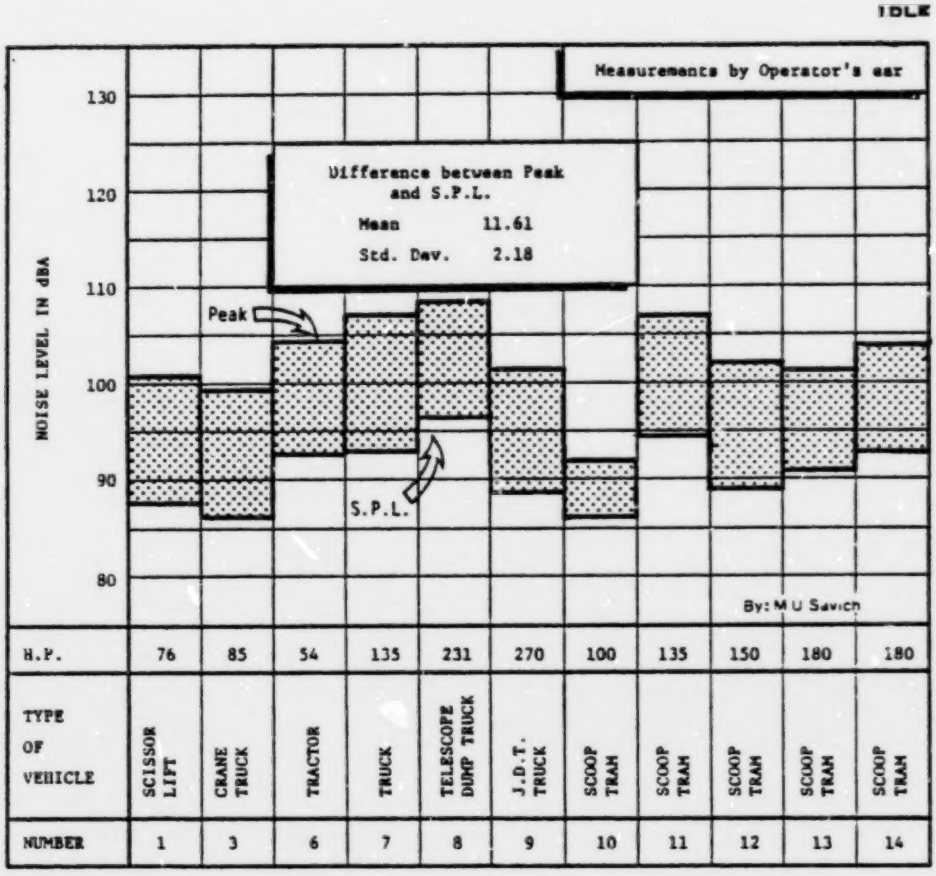
IDLE
Measurements by Operator's ear
NOISE LEVEL IN dBA
130
120
110
100
90
80
Difference between Peak and S.P.L.
Mean 11.61
Std. Dev. 2.18
Peak
S.P.L.
By: M U Savich
H.P. 76 85 54 135 231 270 100 135 150 180 180
TYPE OF VEHICLE SCISSOR LIFT | CRANE TRUCK | TRACTOR | TRUCK | TELESCOPE DUMP TRUCK | J.D.T. TRUCK | SCOOP TRAM | SCOOP TRAM | SCOOP TRAM | SCOOP TRAM | SCOOP TRAM
NUMBER 1 3 6 7 8 9 10 11 12 13 14

Fig. 3 - Graph of differences between the sound pressure level in dBA and the peak value for some vehicles at an idle state of the engine at Stanleigh Mine.

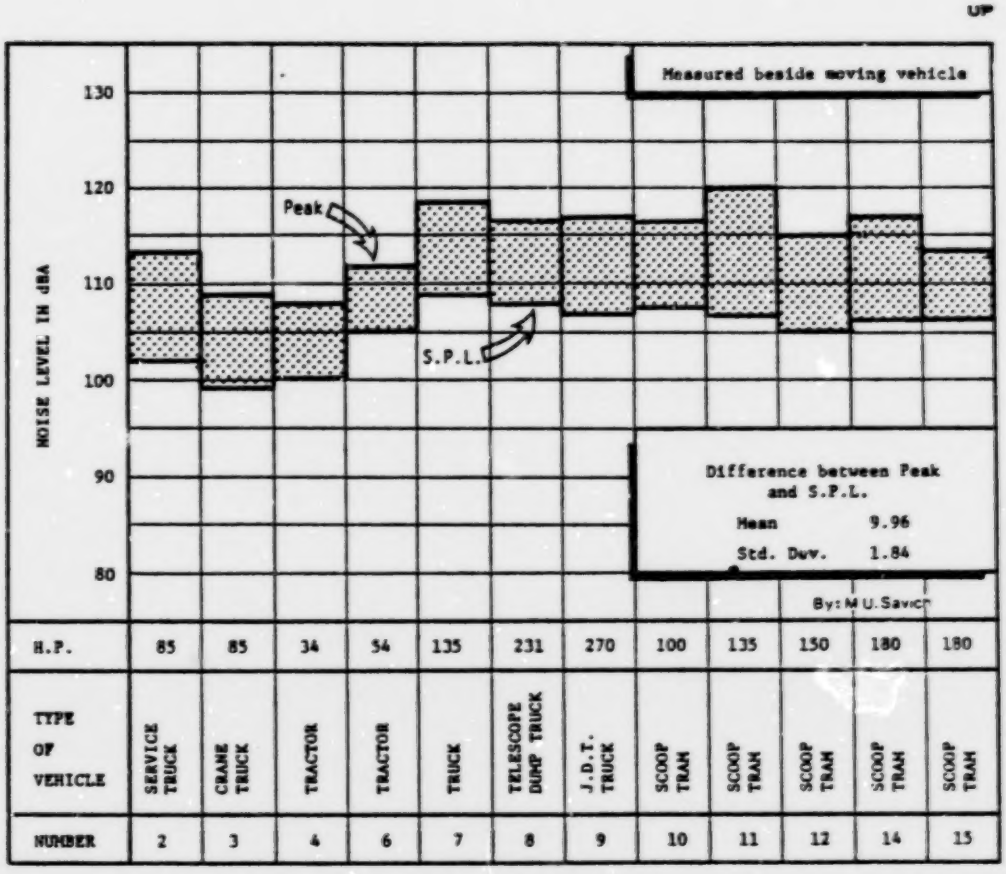
UP
Measured beside moving vehicle
NOISE LEVEL IN dBA
130
120
110
100
90
80
Peak
S.P.L.
Difference between Peak and S.P.L.
Mean 9.96
Std. Dev. 1.84
By: M.U.Savic
H.P. 85 85 34 54 135 231 270 100 135 150 180 180
TYPE OF VEHICLE SERVICE TRUCK | CRANE TRUCK | TRACTOR | TRACTOR | TRUCK | TELESCOPE DUMP TRUCK | J.D.T. TRUCK | SCOOP TRAM | SCOOP TRAM | SCOOP TRAM | SCOOP TRAM | SCOOP TRAM
NUMBER 2 3 4 6 7 8 9 10 11 12 14 15

Fig. 4 - Graph of differences between the sound pressure level in dBA and the peak value for some vehicles moving up a slope at Stanleigh Mine.

DOWN

In Fig. 5 results are shown for vehicles moving down a slope while the surveyor is positioned 1 m away from their sides. Here the mean comes out to be 10.78 dBA with a standard deviation of 2.42 dBA. In this case, as well, differences in results are perceptible. Reasons and causes for this are the same as those of the 'upward slope' case. The No. 11 scooptram (135 hp) again yields the largest difference between SPL and Peak, a difference of 16.9 dBA. Motor power of the No. 11 scooptram is considerably greater than that of the No. 10 scooptram (100 hp) and less than the No. 12 scooptram (150 hp), yet both No. 10 and No. 12 yield markedly smaller differences between SPL and Peak level. From this one can conclude that the No. 11 scooptram should be checked to see whether it needs maintenance. Throughout all tests, including this one, the No. 8 telescope dump truck consistently yielded the lowest difference, of 7.3 dBA.

DISCUSSION OF RESULTS

If we compare the final results of our measurements (namely, the differences between sound pressure levels and peaks), we can see that these results are similar in all cases:

	W.O.T.	IDLE	UP	DOWN
Mean	12.11	11.61	9.96	10.78
Std. Dev.	1.92	2.18	1.84	2.42

These results should most likely be lower by 1 to 2 dBA, because for this type of measurement, usually the mean is taken from 5 measurements (with 5 to 10 second intervals) for Impact Hold and Peak Hold, which in our case was impossible to do. By referring to Table 1 and finding the difference between the peak value and dBA value, the risk criteria for different types of noise,

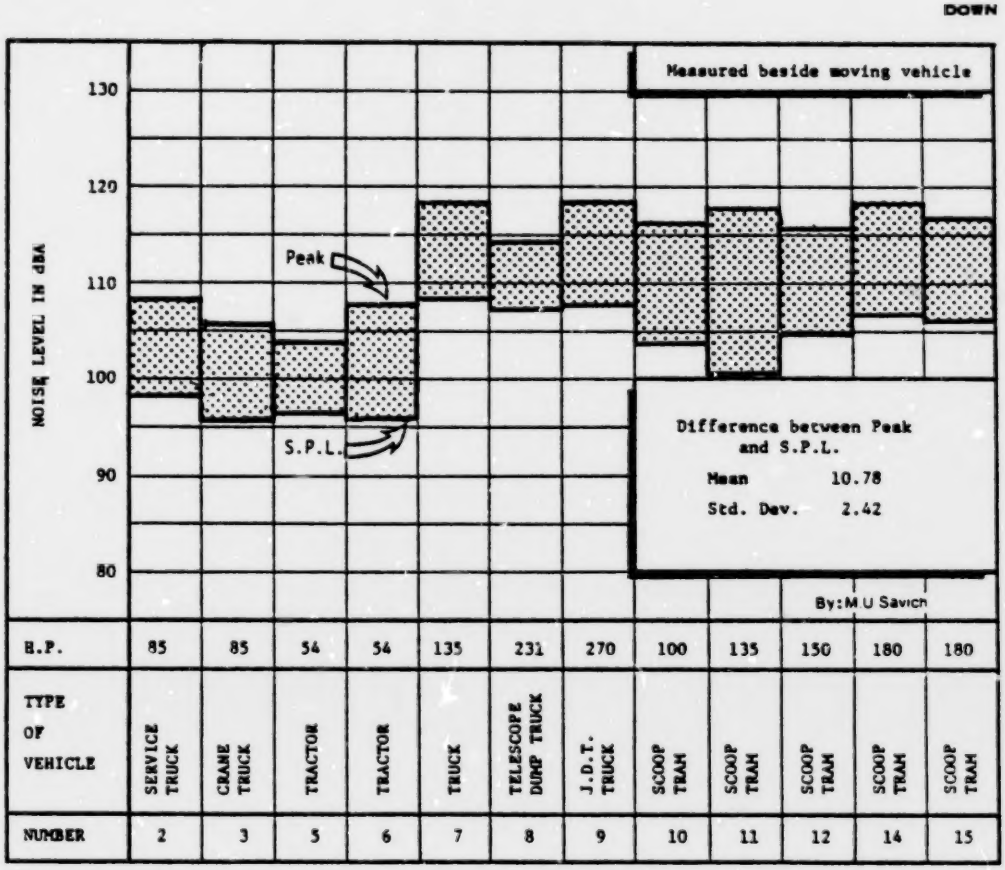
DOWN
Measured beside moving vehicle
NOISE LEVEL IN dBA
130
120
110
100
90
80
Peak
S.P.L.
Difference between Peak and S.P.L.
Mean 10.78
Std. Dev. 2.42
By: M U Savich
H.P. 85 85 54 54 135 231 270 100 135 150 180 180
TYPE OF VEHICLE SERVICE TRUCK | CRANE TRUCK | TRACTOR | TRACTOR | TRUCK | TELESCOPE DUMP TRUCK | J.D.T. TRUCK | SCOOP TRAM | SCOOP TRAM | SCOOP TRAM | SCOOP TRAM | SCOOP TRAM
NUMBER 2 3 5 6 7 8 9 10 11 12 14 15

Fig. 5 - Graph of differences between the sound pressure level in dBA and the peak value for some vehicles moving down a slope at Stanleigh Mine.

Table 1 - The difference between the peak value and dBA value.

Sound Source	Fast dBA	Imp. dBA	Imp/Hold dBA 5x	Peak Hold dBA 5x	Δ
Motorway traffic 15 m distance	80	80	81	89	8
Motorway traffic 50 m distance	68	68	68	76	8
Noise in car Type Fiat 500, 60 km/h	78	79	79	93	14
Noise in car Type Volvo 142, 80 km/h	75	75	76	86	10
75 hp diesel motor in electricity generating plant	100	101	101	113	12

such as motorway, traffic, car interior and diesel motor noise can be found (6).

The results in Table 1 were obtained using a B & K Sound Level Meter Type 2209 with a 'Hold' circuit for peak voltage measurements, which with the A-filter coupled in, has an averaging time of 30 us for peak measurements. For our measurements we used a B & K Integrating Sound Level Meter Type 2225 with 'Slow' and 'Fast' time constants, and a 'Peak Hold' better than $\pm$ 01 db/s, with a 30 us rise time.

The Type 2205 instrument and a new generation of similar instruments could be adapted successfully, in combination with level recorders, for this kind of measurment. The most interesting aspect in this connection is to find out how large the 'Peak' value is above dBA 'Fast' or dBA 'Impulse'. The larger this difference is, the more hazardous is the noise. However, this method of measurment requires additional expensive instruments and qualified surveyors. For small and mid-size mining operations these factors make the method practically unaffordable. Thus the reason for this project: facilitating the taking of four main measurements (W.O.T., IDLE, UP and DOWN) of vehicles, where measurment is usually most difficult, by using relatively inexpensive instruments. Furthermore, the project aims to ascertain whether, on the basis of these measurements, results can be standardized for mining machinery. Today, standardization is very important in laying down normative specifications from the point of view of internal requirements first of all. "However, in the actual process of standardization, more extensive technical interests have to be taken into account. Work standards and normative specifications dealing with a limited area - mining instruction sheets, for example - are to be recognized as a preliminary stage of standardization" (9).

In our work to measure the Noise Exposure Index (NEI) we use a

profiling dosimeter which can generate 480 results in 8 hours. Measurement results are closely related to the work and relationship of workers and machines. In other words, these results are a time study of each worker. If we could obtain systematized results in dBA of 'Impulse' and 'Peak' values of varying duration for each piece of equipment, and if we could pass this data through an existing computer program, we would end up with very valuable results.

In this way mining companies would not have to increase their budgets in order to hire for new positions and purchase expensive instruments. Only in exceptional circumstances would supplementary measurements have to be taken, and this in larger mines, where not everything can be measured and predicted.

CONCLUSION

The mining industry is obliged to cooperate in the establishment of safety regulations in noisy environments because these regulations demand constant check-up measurements, measurement simplification, and the assurance that results will not depreciate in value. To measure impulse or impact noise in underground areas it is best that measurements be carried out from one place, or failing that, in as few places as possible so as to have constant reverberation time. From this it follows that the results used will be accurate.

Measurements and evaluations for determining peak levels of short duration of vehicle noises were carried out for the following engine states: Wide Open Throttle (W.O.T.), IDLE, and under the working conditions of moving up a slope (UP), and down a slope (DOWN). The mean value of these measurements is about 11 dBA. Some authors treat impulse noise as a serious

health hazard. Hearing loss always starts in the 4-6 kHz range because the peaks in industrial noise contain significant amounts of energy in this frequency region.

At the Fourth International Congress on Noise as a Public Health Problem held in Turin, Italy, in June 1983, the Workshop Memorandum recognized that 'Impulsiveness' requires 'characterization in relation to its biological significance'. A minimum of five years of research would be needed before the method of ISO/DIS 1999-1984 could be improved upon. With increasing scientific knowledge relating to effects of occupational noise exposures and aspects of noise measurement and control, a new ISO standard with new requirements should appear within 5 years. For this reason the Elliot Lake Laboratory has begun work on the above-mentioned problem, to enable Canada's mining industry to meet the new requirements if that becomes necessary.

This test has been the most difficult, because it required expensive, yet bulky, instruments, suitable natural conditions and a large number of different vehicles in one place. Tests on the ventilation system at Rio Algom are already complete (7). All other tests on mining machinery have also been completed, in the mines, mills and smelter at Falconbridge.

ACKNOWLEDGEMENTS

The authors wish to express their gratitude to Ian Montgomery, Ventilation Engineer, Rio Algom Ltd., Elliot Lake, for his approval to conduct this survey and for his interest in the project. The authors also acknowledge the assistance they received from A. Mannisto and W. Howard, the Ventilation Officers at Stanleigh, and D. Restoule, the Union Environment Monitor at Stanleigh. Also acknowledged is the support of the Elliot Lake Laboratory through M. Turcotte.

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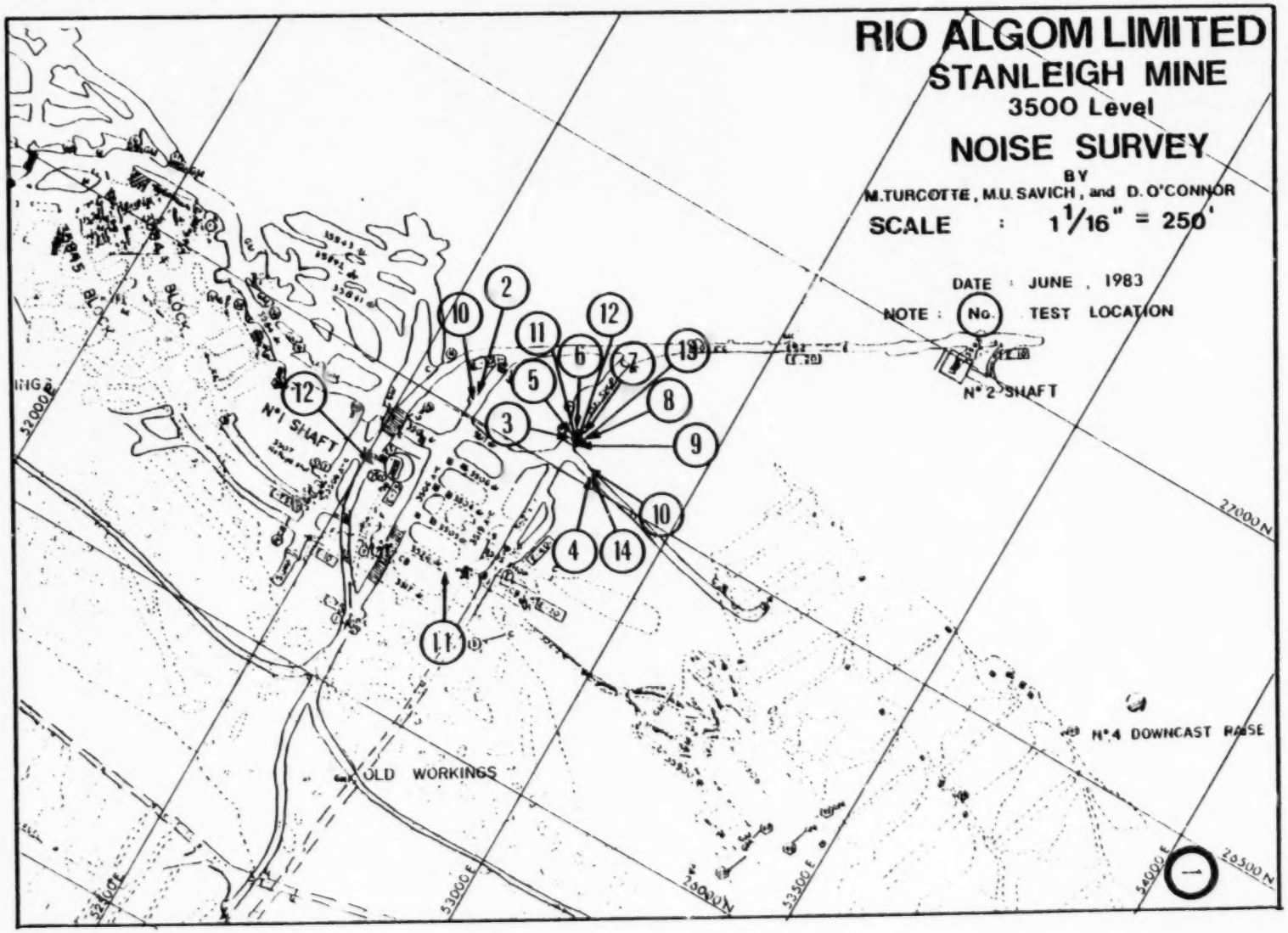
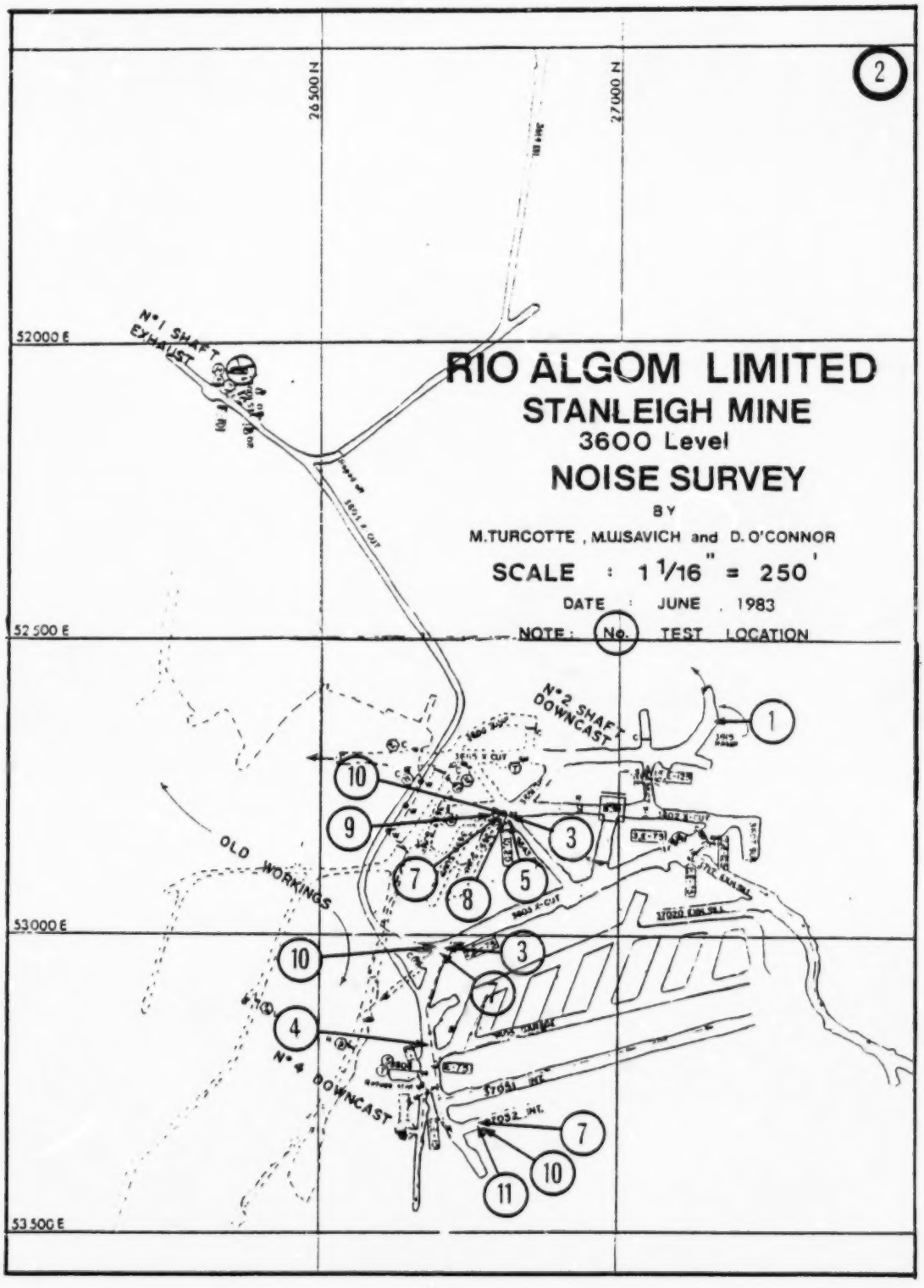
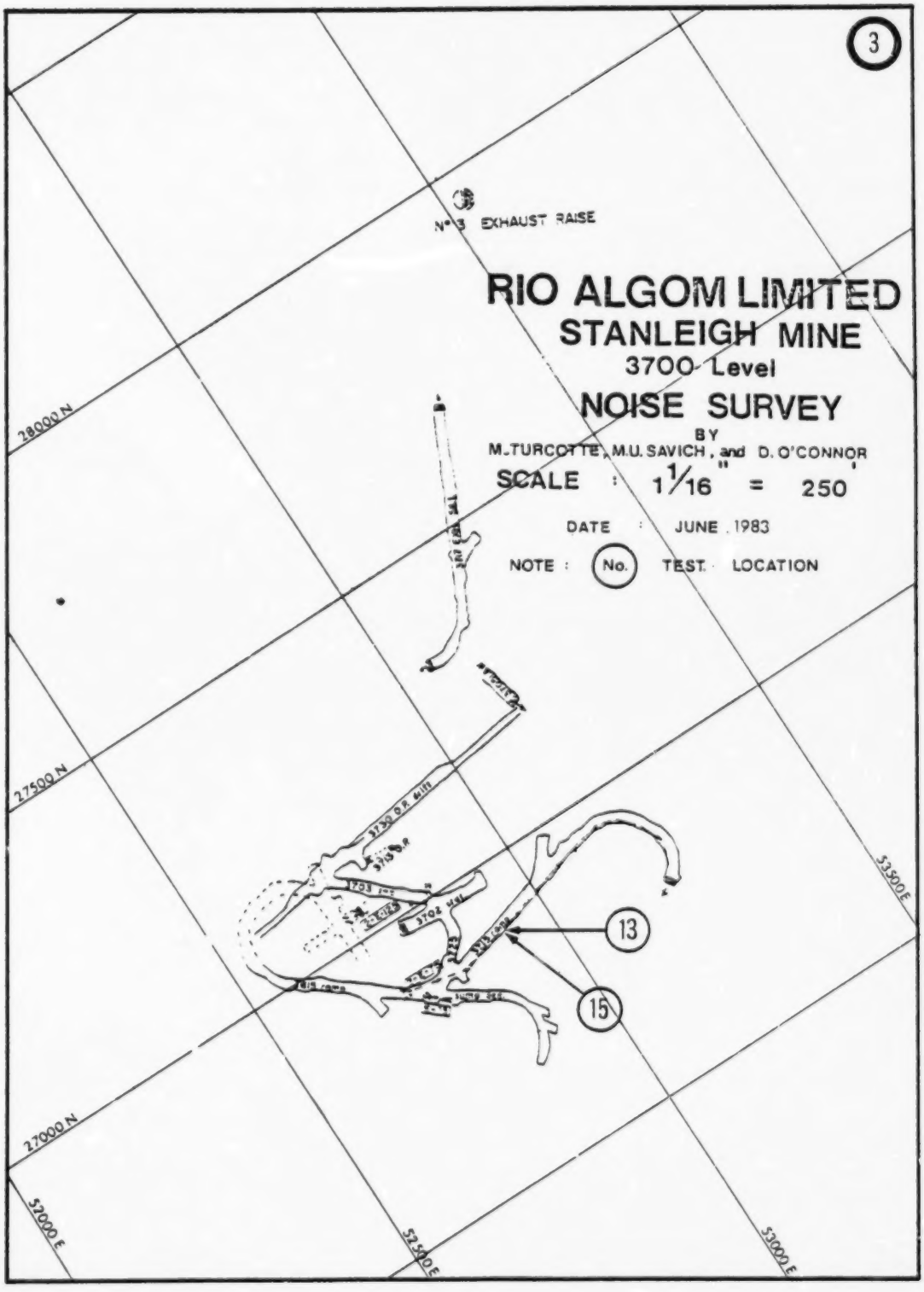
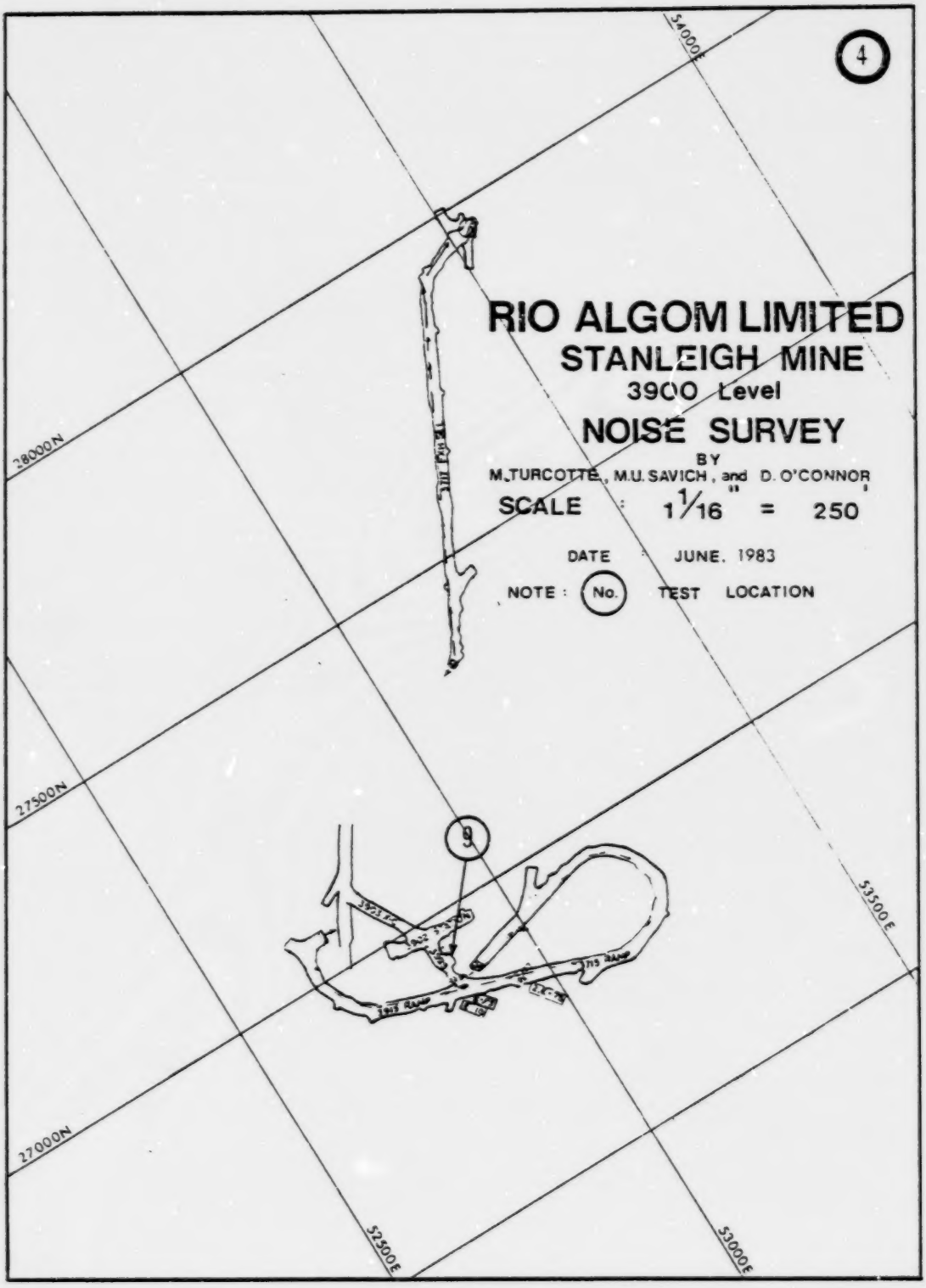
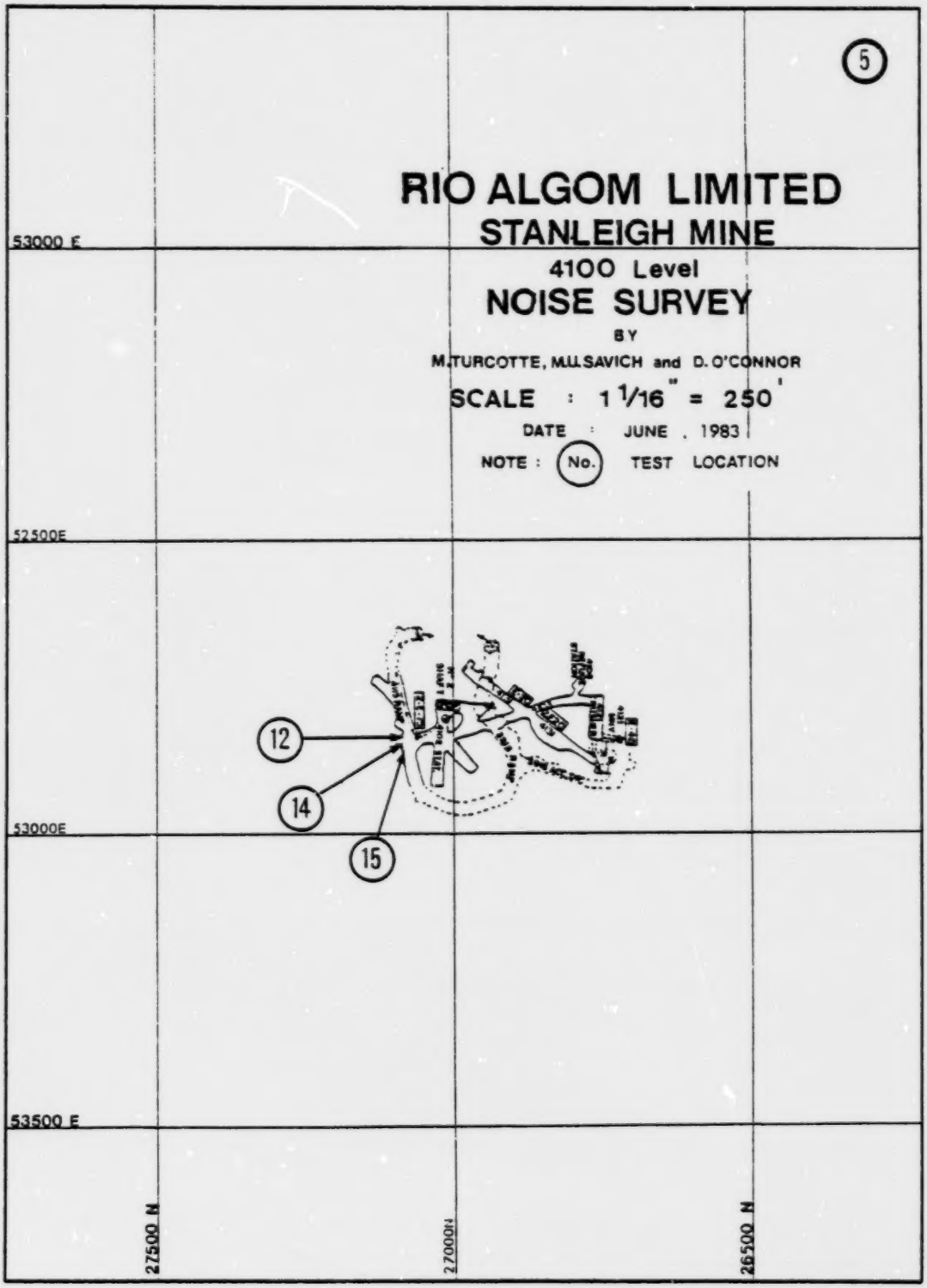

RIO ALGOM LIMITED
STANLEIGH MINE
3500 Level
NOISE SURVEY
BY
M.TURCOTTE, M.U.SAVICH, and D.O'CONNOR
SCALE : 1 1/16" = 250'
DATE : JUNE , 1983
NOTE : (No.) TEST LOCATION
N° 1 SHAFT
N° 2 SHAFT
N° 4 DOWNCAST RAISE
OLD WORKINGS
52000E
53000E
53500E
54000E
27000N
26500N
25500N


2
26500 N
27000 N
52000 E
52500 E
53000 E
53500 E
N° 1 SHAFT EXHAUST
N° 2 SHAFT DOWNCAST
N° 4 DOWNCAST
OLD WORKINGS
RIO ALGOM LIMITED
STANLEIGH MINE
3600 Level
NOISE SURVEY
BY
M.TURCOTTE , M.WISAVICH and D. O'CONNOR
SCALE : 1 1/16" = 250'
DATE : JUNE , 1983
NOTE: (No.) TEST LOCATION


3
N°3 EXHAUST RAISE
RIO ALGOM LIMITED
STANLEIGH MINE
3700 Level
NOISE SURVEY
BY
M. TURCOTTE, M.U. SAVICH, and D. O'CONNOR
SCALE : 1 1/16 " = 250 '
DATE : JUNE, 1983
NOTE : (No.) TEST LOCATION
28000 N
27500 N
27000 N
32000 E
32500 E
33000 E
33500 E
13
15


4
RIO ALGOM LIMITED
STANLEIGH MINE
3900 Level
NOISE SURVEY
BY
M.TURCOTTE, M.U.SAVICH, and D.O'CONNOR
SCALE : 1 1/16" = 250'
DATE : JUNE, 1983
NOTE : (No.) TEST LOCATION
9
54000E
28000N
27500N
27000N
52500E
53000E
53500E


5
RIO ALGOM LIMITED
STANLEIGH MINE
4100 Level
NOISE SURVEY
BY
M.TURCOTTE, M.LSAVICH and D. O'CONNOR
SCALE : 1 1/16" = 250'
DATE : JUNE , 1983
NOTE : (No.) TEST LOCATION
53000 E
52500E
53000E
53500 E
27500 N
27000N
26500 N
12
14
15

Measurement Results

Engine states: W.O.T. - IDLE

Number	Appendix A	No. of Vehicles	VEHICLE INFORMATION			NOISE LEVEL IN dBA	
			Type	Factory	b.p.		80 85 90 95 100 105 110 115 120
1	2	1	Scissor lift	Jarvis Clark	76	W.O.T.	XXXXXXXXXXXXXXXXXXXXXXXXXXXX + S.P.L. OOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOO - Peak
						IDLE	XXXXXXXXX - S.P.L. OOOOOOOOOOOOOOOOOOOOOOOOO - Peak
2	1	1	Service truck	Teledyne	85	W.O.T.	XXXXXXXXXXXXX - S.P.L. OOOOOOOOOOOOOOOOOOOOOOOOOOOO + Peak
						IDLE	
3	1 2	3	Crane truck	Teledyne	85	W.O.T.	XXXXXXXXXXXXXXXXXXXXX - S.P.L. OOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOO -Peak
						IDLE	XXXXXXX - S.P.L. OOOOOOOOOOOOOOOOOOOOO + Peak

Working condition: UP - DOWN

Number	Appendix A	No. of Vehicles	VEHICLE INFORMATION			NOISE LEVEL IN dBA	
			Type	Factory	b.p.		80 85 90 95 100 105 110 115 120
2	1	1	Service	Teledyne	85	UP	XXXXXXXXXXXXXXXXXXXXXXXX - S.P.L. OOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOO + Peak
						DOWN	XXXXXXXXXXXXXXXXXXXX - S.P.L. OOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOO - Peak
3	1 2	3	Crane truck	Teledyne		UP	XXXXXXXXXXXXXXXXXXXX + S.P.L. OOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOO - Peak
						DOWN	XXXXXXXXXXXXXXXXXX - S.P.L. OOOOOOOOOOOOOOOOOOOOOOOOOOOO - Peak
						UP	
						DOWN	

Measurement Results

Engine states: W. O. T. – IDLE

Number	Appendix A	No. of Vehicles	VEHICLE INFORMATION			NOISE LEVEL IN dBA		80	85	90	95	100	105	110	115	120
			Type	Factory	h.p.											
4	2	1	Tractor	Ford	34	W.O.T.	XXXX

Measurement Results

Engine states: W. O. T.-IDLE

Number	Appendix A	No. of Vehicles	VEHICLE INFORMATION			NOISE LEVEL IN dBA	
			Type	Factory	h.p.		80 85 90 95 100 105 110 115 120
7	2	2	Truck	Jarvis Clark	135	W.O.T.	XXXX

Measurement Results

Engine states: W.O.T. – IDLE

Number	Appendix A	No. of Vehicles	VEHICLE INFORMATION			NOISE LEVEL IN dBA	80 85 90 95 100 105 110 115 120
			Type	Factory	h.p.		
10	1 2	3	Scooptram	Elmco	100	W.O.T.	- S.P.L. - Peak
						IDLE	- S.P.L. - Peak
11	1 2	2	Scooptram	Wagner	135	W.O.T.	- S.P.L. - Peak
						IDLE	- S.P.L. - Peak
12	1 5	1	Scooptram	Wagner	150	W.O.T.	-S.P.L. - Peak
						IDLE	- S.P.L. - Peak
13	3	1	Scooptram	Wagner	180	W.O.T.	- S.P.L. - Peak
						IDLE	- S.P.L. - Peak
14	1 5	1	Scooptram	Wagner	180	W.O.T.	- S.P.L. - Peak
						IDLE	- S.P.L. - Peak
15	3	1	Scooptram	Jarvis Clark	180	W.O.T.	- S.P.L. - Peak
						IDLE	

Measurement Results

Working condition: UP-DOWN

Number	Appendix A	No. of Vehicles	VEHICLE INFORMATION			NOISE LEVEL IN dBA	
			Type	Factory	h.p.		80 85 90 95 100 105 110 115 120
10	1 2	2	Scooptram	Elmco	100	UP	S.P.L. Peak
						DOWN	S.P.L. Peak
11	1	1	Scooptram	Wagner	135	UP	S.P.L. Peak
						DOWN	S.P.L. Peak
12	1	1	Scooptram	Wagner	150	UP	S.P.L. Peak
						DOWN	S.P.L. Peak
14	1	1	Scooptram	Wagner	180	UP	S.P.L. Peak
						DOWN	S.P.L. Peak
15	3	1	Scooptram	Jarvis Clark	180	UP	S.P.L. Peak
						DOWN	S.P.L. Peak